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Round Table

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What Do We Know about Tooth Decay?

An NBC Radio Discussion by

JAMES ROY BLAYNEY, H. TRENDLEY DEAN
C. A. ELVEHJEM, *and* FRANK J. ORLAND

Including

A NUTRITIONIST'S VIEW OF THE CARIES PROBLEM

By C. A. ELVEHJEM

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THE UNIVERSITY OF CHICAGO ROUND TABLE

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What Do We Know about Tooth Decay?

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DR. BLAYNEY: Tooth decay is a disease of civilization. If we examine those people now living in remote areas of the globe and under their native or natural conditions, we find many who are totally free from tooth decay and some who have only a few cavities. When these same people are brought in contact with the white man and adopt his manner of living, tooth decay immediately begins to appear and progresses at a rapid rate.

On the contrary, civilized man has approximately a 98 per cent rate of tooth decay. The increase of the disease of the teeth is in marked contrast to the situation with relation to other diseases, where our science has been highly successful in controlling and preventing disease.

Why is it that tooth decay is so prevalent in our society? What do we know about the cause of tooth decay which would explain this increase? Today we propose to discuss some of the recent work done on the problems of tooth decay and to tell you what we do know about it. Dr. Dean, what is it in our mouths which makes our teeth so susceptible to tooth decay?

DR. DEAN: If nature had made our modern teeth with something more resistant to the acids of the mouth than the type we now have, we probably would not suffer from the amount of decay which we have. But, since we have this acid action in the mouth, I hope that somehow we can change the climate around the tooth surface and make the tooth surface more resistant to the actions of the acids. The other possibility is that we could get rid of the bacteria in our mouth which produces this acid. Is there evidence of success in this particular field, Dr. Orland?

DR. ORLAND: Our tooth surfaces, as you intimate, are teeming with bacteria. They are found everywhere in the mouth, but it is only when

certain types of bacteria become concentrated at one point on the tooth surface that acids begin to accumulate, and these can harm the enamel. Of course, if the bacteria did not get any food, they could not live and could not produce acid. But we cannot stop eating food in order to starve these bacteria.

MR. ELVEHJEM: Bacteria are like every other living organism; they must have food to live. Unfortunately, the bacteria get this food by breaking down sugar into acid, and the acid is what causes the trouble. Since we also must have food, and because we get most enjoyment from food by consuming it through the mouth, some of it obviously becomes available to the bacteria.

DR. BLAYNEY: Our problem, then, is to find a way to check tooth decay in our modern society. You gentlemen have mentioned three points regarding the causes of tooth decay which I like to use in discussing the situation with my patients. I describe it as a three-legged stool. When all three legs are present, the stool is stable; but if you remove any one of the legs, the stool immediately topples over. I call these three legs: (1) a susceptible tooth; (2) foods in the mouth which are constantly present; and (3) bacteria.

Let us now turn to this first problem—the tooth itself. Can we develop teeth which are resistant to decay? What can we do to protect susceptible teeth? Is there any hope in this regard?

DR. ORLAND: I think that, if we can do anything, we have to start with children while the teeth are first being formed.

MR. ELVEHJEM: If our hope is with children, are we doing anything for our children?

DR. DEAN: Yes, we surely are. In sixty cities in this country fluorides are now being added to the public water system. We are doing this specifically for the purpose of reducing the amount of general decay in the children's teeth. As Dr. Orland has pointed out, we must start with children. In all these cities where fluoridation has gone on three or four years, a general reduction of general decay in the younger children has been noted. In the cities using this procedure for about four years or more reductions of from 35 to 40 per cent have already been observed.

DR. ORLAND: Is it safe?

DR. DEAN: It is quite safe. And, furthermore, we are not adding anything to a public water supply which a couple of million people have not been using for years in this country where it has existed in the natural water supply.

DR. ORLAND: Of course, it might be added that we are not speaking of the element fluorine itself, which is a gas, but of a chemical compound, fluoride salt, which is the main object of our interest in this regard.

DR. DEAN: That is quite right, because fluorine itself is very rare.

DR. BLAYNEY: How extensively is it being used at the present time?

DR. DEAN: There are about sixty cities where fluorine is being added artificially at present, with the very strong possibility that this number will be considerably increased in the next year.

DR. BLAYNEY: You do find fluorine occurring naturally in the water in certain communities, as you have already hinted.

DR. DEAN: Yes. There are probably, as I said, a million to two million people using naturally fluorinated public water supplies. Specifically, these places are located in western Texas and in Colorado and South Dakota and a few places in Illinois. In fact, it was from areas with higher fluoride content in the water that this natural phenomenon was first observed. The marked difference in the amount of dental caries in these different populations was observed in those places where the fluoride content in the water was higher. In fact, as we talk here in Chicago, there is no better illustration than several communities right here in the suburbs. The city of Aurora, for instance, which has 1.2 parts of fluorine per million parts of water occurring naturally in its water and which has used this water for fifty years has only about a third as much dental decay as the near-by city of Waukegan, using the relatively fluoride-free Lake Michigan water.

And, if we go downstate, we can see the same thing where Quincy, using the Mississippi River water, has over three times as much dental decay as Galesburg, which uses well water which has about 1.8 parts fluorine per million parts in its water.

DR. BLAYNEY: Does this water come from deep wells?

DR. DEAN: Generally speaking, it is from deep wells—all this in Illi-

nois, for example. One of the few exceptions is Colorado Springs, whic takes its water from Pikes Peak.

DR. BLAYNEY: How deep do they have to go to get well water contain ing fluorine? Is there any regularity to it?

DR. DEAN: That does vary a great deal because of geological forma tion. At Galesburg the water comes from about twenty-four hundre feet. At Maywood and Aurora it is found at twelve or thirteen hundre feet; and you can find high fluorine waters in West Norfolk no deepe than ninety or a hundred feet.

DR. ORLAND: When you artificially fluoridate water, is there any tast added?

DR. DEAN: There is no taste at all.

DR. ORLAND: And is that a very cheap method of controlling toot decay?

DR. DEAN: It is a very cheap method, and it is going to become eve cheaper. In Grand Rapids, Michigan, which uses sodium fluoride in th water, the cost is about eleven cents per person per year. With the use o sodium fluorosilicate, which in all probability will be used in preferenc to sodium fluoride (and I think that Racine, Wisconsin, is using it now the cost will come down to about four cents per person per year.

MR. ELVEHJEM: What are we going to do about those people who d not have access to a city or a central water supply?

DR. DEAN: I am glad you brought that question up because, when w talk about public water supplies, we are talking about only 63 or 64 pe cent of the population. Mass fluoridation of the public water supply ob viously would not apply to rural populations and very small commun ties. In these cases we will probably use topical fluoride application, o such other control measures which are effective.

DR. ORLAND: By "topical application," of course, you mean the dire application of the fluoride to the tooth. The dentist paints on a 2 per cen fluoride solution by four applications a week apart, at three, seven, te and thirteen years of age.

DR. BLAYNEY: Although we seem to note the very striking results on gets in the reduction of tooth decay by this method, do we know how works?

DR. DEAN: No, we do not know how it works. But, in the history of eventive medicine, there are a number of instances where an actual enomenon has been observed which curtails disease; and a century or ore may pass before we find out the method of action or how it works. ood examples of that, of course, are controls of smallpox with cowpox rus, malaria, and scurvy, and so forth, even though we did not know r a long time how they worked.

DR. BLAYNEY: What do you anticipate the effectiveness will be of the neral use of fluorides, either in the communal water supply or by top- l application?

DR. DEAN: I expect that, through the fluoridation of public water sup- es which are in the natural state relatively free of fluorine or are very v (only one-tenth of a part per million), after a lapse of twelve, thir- n, or fourteen years, we should see about 60 to 65 per cent reduction in e amount of dental decay in that population.

DR. BLAYNEY: Do you think that it makes any difference in the amount caries which children will have if their parents have lived in a fluoride- ntaining area? Is there any relationship there?

DR. DEAN: We have no evidence on that particular point. All these dies were based upon children who continuously resided in the area study.

DR. BLAYNEY: You did not study their ancestry, did you?

DR. DEAN: We did not go back further than studying the children iding continuously in the area.

DR. BLAYNEY: It is generally recognized that people have quite a riance in their susceptibility to tooth decay. Does heredity play any le in that, do you think?

DR. DEAN: That is a question which has been brought up a number times, but I know of no sound acceptable scientific evidence which dicates that heredity is a factor in tooth decay in human populations.

DR. BLAYNEY: We have discussed something of the problem of this st leg of the tripod—what we know about and are doing to the sus- otible tooth. We might now go on over into the second area—that is, mely, the consideration of foods in the mouth. What do we know out nutrition which can be successfully applied to prevent tooth decay?

MR. ELVEHJEM: First, before going into nutrition, I would like to a
if there is any evidence in relation to heredity? Dr. Dean has indicate
great decrease due to the use of fluorine, and yet there is considera
variation between individuals, even in the areas where the water conta
fluorine. Do you know of any effect of heredity on dental caries?

DR. DEAN: No, I do not. That has come up a number of times, b
there is no acceptable evidence of which I know in relation to the hum
population.

MR. ELVEHJEM: We do, however, have some experience with anima
We find that the offspring from different female rats show considera
variation in the development of caries; and, by using these standardiz
rats, we have been able to establish a few fundamental facts about t
relation of nutrition to dental caries.

DR. BLAYNEY: Would you tell us about them?

MR. ELVEHJEM: We have used the typical purified ration which is n
widely used in nutritional laboratories, and we find that if this ration
rather high in carbohydrate, especially in table sugar or cane sugar,
have an incidence of caries which is phenomenally high. We have
high as thirty lesions in the mouth of a single rat. Now, I want to emp
size that this ration is complete in all nutritional respects. We can
decrease this incidence by adding any of the known nutrients. We c
however, reduce the incidence by changing from so-called "solub
sugars to starches. And, by doing this, we can reduce the incidence do
to about five lesions per rat. We can also do it by decreasing the amou
of carbohydrate and increasing the amount of fat and protein. I thi
that the most important finding which we have made recently in o
laboratory is that, if we feed these animals whole mineralized milk, th
develop no caries whatsoever.

DR. ORLAND: Does that mean that milk has a protective factor?

MR. ELVEHJEM: No, I do not believe that it does. I think that it is m
likely to be due to the fluidity of the ration. That is, if we fed dried mi
we would get a greater incidence of caries. This fact may have so
practical significance. I do not think that we can all eat liquid or fl
diets. But we can tend to increase our water consumption, especiall
glass of water after a meal.

DR. BLAYNEY: You have said something about sugar in the diet. How much sugar is in the average American diet?

MR. ELVEHJEM: We have continued some of our studies, attempting to simulate a typical American diet by mixing together typical foods, such as cereals, potatoes, dried meat, and dried vegetables. In such a diet, we find that it contains about 17 per cent sugar, which is rather typical of the American diet. Now, it is very interesting that even on this diet we have considerable incidence of caries; and even if we put in natural sugars, rather than the so-called refined sugars, we do not seem to get much difference. But there is, I think, good evidence in recent human studies that we can reduce caries by decreasing the consumption of sugar.

DR. BLAYNEY: How much sugar is really needed in our diet for adequate nutrition? That is a point in which I have been very much interested. As an authority on nutrition, I would like to have you discuss that.

MR. ELVEHJEM: Of course, the sugar can actually be reduced to very, very small amounts. It is unnecessary to add any sugar so far as nutrition is concerned. That brings us, of course, to our tastes and whether we like sugar or not.

I want to come back to these studies on human beings which I mentioned. I think that the best evidence which we have is the studies made by Toverud in Norway during World War II. He studied between four and seven hundred preschool children and eight to nine thousand school children. He found that the number of caries-affected teeth dropped 50 per cent, and the number of caries-affected tooth surfaces dropped from as high as 80 per cent, during wartime when the consumption of sugar was very low. During the war the consumption of sweets and refined carbohydrates was greatly reduced, and there was an increase in high-extraction flour, potatoes, vegetables, and fish.

DR. BLAYNEY: Then you really believe that that is a study on the human which parallels your study on laboratory animals as to the role that an excessive amount of sweets plays in the production of tooth decay?

MR. ELVEHJEM: I think that here there is good correlation. It is always difficult, of course, to interpret animal experiments, but in this particular case I think that there is excellent correlation. And I might add that shortly after the war, when the consumption of sugar increased in these European countries, the incidence of caries also increased.

DR. BLAYNEY: Every day I am asked by my patients what they can d to prevent tooth decay and what type of food they should consum Would you mind giving us your idea of what a good general die should be?

MR. ELVEHJEM: We have found, in our animal studies, that the actua physical state of the diet is very important, and perhaps the processin of our modern foods may not destroy essential nutrients so much a change the physical state of the food. This, I think, has considerabl effect on allowing the bacteria to grow in the mouth, as Dr. Orland indi cated a little earlier.

DR. ORLAND: Yes, what is food for the individual person is also foo for the countless number of bacteria living in his mouth. Of even thes tiny creatures, the bacteria around teeth, even though first observe some two hundred and sixty years ago by Leeuwenhoek, the Dutc lens-grinder, still we are not able to take complete census today. It ha been estimated, though, that the many bacteria living in a normal huma mouth are as numerous as the people on the face of the earth.

MR. ELVEHJEM: Does the kind of bacteria have any effect, the species I should say?

DR. ORLAND: Yes. One should say that, of all these bacteria, most o them are purely harmless one-cell creatures living on the food left in an around the teeth. But research evidence available at the present tim seems to indicate that some of these bacteria living in intimate contac with the teeth are able to split sugar molecules into acid.

MR. ELVEHJEM: And that is particularly the lactal bacilli?

DR. ORLAND: Very likely a lactal species might be one of the causativ factors; perhaps others are those which are considered to be streptococci Nevertheless, the acid evidence indicates that it is completely capable o attacking the hard enamel of the tooth and tends to dissolve it.

DR. BLAYNEY: Do you think that the frequency with which we plac food in our mouth—that is, the habit of eating between meals—ha any role in the amount of activity of the bacteria—that is, the amount o acid that they may produce?

DR. ORLAND: I think so, Dr. Blayney. The evidence seems to be that i is the frequent eating which causes rapid acid production and the eating

way at the tooth by this acid on repeated occasions which is the prime vil in tooth decay.

MR. ELVEHJEM: We certainly found that to be true in the case of our xperimental animals.

DR. BLAYNEY: That is, those that you let feed frequently have more aries than those that are fed at stated intervals?

MR. ELVEHJEM: Yes, those with restricted food intake; that is right.

DR. ORLAND: And then, of course, one can say that once the cavity eaches the softer dentine, after going through the enamel, then other acteria surely take part and the cavity gets bigger a great deal faster.

DR. BLAYNEY: That does seem to bring up the problem of what tooth ecay is. Let us talk about that. We have been talking about food and acteria producing an acid; how do we recognize this tooth decay?

DR. ORLAND: From the bacterial standpoint we might visualize each cid-producing bacterial cell as a tiny factory on a hidden tooth surface. t turns out acid very rapidly, and merely as a by-product for energy, vhenever sugar is made available to these cells. The question, of course, nen arises of how we can stop these bacteria from doing this.

DR. BLAYNEY: Then, on that basis, we can think of tooth decay as a issolution of the mineral or the inorganic parts of the tooth enamel and entine, primarily as a result of acid production.

DR. ORLAND: From the best evidence available that seems to be what eople agree on, though there are a few dissenters in that field.

DR. BLAYNEY: Of course, the general public thinks of tooth decay as a ole in the tooth or when the tooth becomes sensitive. But I think that ne well-trained dentist recognizes tooth decay long before it gets to the oint of where there is a hole. The very early action of the acid on the namel can be recognized by careful observation.

DR. ORLAND: That is certainly true, and under the microscope we can ee, as bacteria progress, how the tooth actually falls apart, so to speak.

DR. BLAYNEY: What can we do about neutralizing these acids, or, that , what can we do to reduce the activity of bacteria in the mouth?

DR. ORLAND: As Elvehjem stated earlier, we can certainly try to starve nem, let us say, by not giving them their vitamins. But, unfortunately,

the bacteria need the same vitamins as those needed by man himself. Perhaps then we could deprive the bacteria of the mouth of something else that man does not need. Sugar has been stated, when used in excessive amounts, as being such a substance.

DR. BLAYNEY: Now, how about sugar in fruits; does that do the same thing? What type of sugar are you thinking of in feeding the bacteria?

DR. ORLAND: Usually it is the sugar which is served right on the table. "Sucrose" is the term for that sugar.

MR. ELVEHJEM: Of course, the sugar in fruits would also be available to these bacteria. And in this connection, of course, we hear a great deal these days about the various acids in fruit as having some effect on the enamel.

DR. BLAYNEY: It certainly is true for people who take an excessive amount of fruits that contain a large amount of acid.

MR. ELVEHJEM: Especially lemons.

DR. BLAYNEY: That is right. Lemons will produce decalcification or dissolution of the enamel in the anterior portion of the mouth. This work was reported some little time ago.

MR. ELVEHJEM: But that is entirely different from caries?

DR. BLAYNEY: That is quite different from acid production on the tooth surface by the bacterial masses which accrue to the surface; the two must not be confused.

MR. ELVEHJEM: That is more like erosion than it is caries.

DR. BLAYNEY: That is right. It is a smooth, entirely different process.

MR. ELVEHJEM: It is a loss of substance.

DR. ORLAND: To go back to the problem of the bacterial process on the tooth surface, I think that we can also remove sugars, which may be found around teeth, and dilute them by rinsing even with plain water. Even more effective means are sometimes practiced. They include the use of certain chemical substances which will act as poisons preventing growth of bacteria or actually killing them, again using them in rinsing or brushing perhaps, the area around the tooth. And certainly, Dr. Dean in your experience with the use of fluorides, it has been well shown that they are a bacterial poison and a highly potent one at that.

DR. BLAYNEY: What about these ammoniated dentrifices? How do hey affect the bacterial activity? Do they kill the bacteria? Just what is heir action on micro-organisms?

DR. ORLAND: What we should point out there is that ammonia, when t is in great concentrations, will inhibit bacteria. That can be demonstrated in test tubes. In the mouth it is a little difficult to understand ow it can be accumulated in sufficient concentration.

MR. ELVEHJEM: Is there enough ammonia in the mouth to reduce the acteria?

DR. ORLAND: That is the point. It is a bit of a question; and the clinical results which have been observed after its use show that there is only a slight reduction of tooth decay by the use of some of these preparations. I should say, though, that I believe that it still is certainly worth using.

DR. BLAYNEY: With the present development of the antibiotics which are used so frequently now in the control of other diseases, what effect do they have upon the bacteria which cause caries? What do you think about the use of antibiotics for the control of tooth decay if they work?

DR. ORLAND: Certainly, as they were first used in the test tube, they were very effective in stopping bacteria from growing, and they even killed them. In the mouth some of the studies with children now have also shown that they are effective in limiting the amount of new cavities which are formed. However, with the use of such a potent antibiotic as penicillin, for example, we must be very cautious so that we do not run into other difficulties and reactions.

DR. BLAYNEY: How frequently do you have to apply these antibiotics? Every day or every other day or once a week? Have you any evidence on that?

DR. ORLAND: The experience of the group which studied their use was that they should be used as a tooth powder at least twice every day by brushing them right around the tooth surfaces where the bacteria are in great masses.

DR. BLAYNEY: It is generally known that about $1\frac{1}{2}$ to 2 per cent of our population are totally free from tooth decay. What is it which exists in the mouths of these people which keeps the bacteria from acting? Or, do you find the same type of bacteria in the mouths of these people

who do not have tooth decay under any condition? What makes thi difference?

Dr. Orland: That has been a very interesting problem for a goo number of years now. Certain neutralizing agents which are found i saliva have been considered. But these are not definitely known in all in stances. It is also suspected that in the normal bacteria flora of the mouth that is, the normal forms which are usually found, if they are there in such numbers, some of these acid-producing forms might not be able t find life in the presence of other types. Hence we do not get the sam picture of bacteria relationship in those mouths.

Dr. Blayney: Could there be a natural antibiotic in these mouths

Dr. Orland: That is one of the agents which has been identified from time to time but never in very great concentrations.

Dr. Blayney: Does it not appear also that certain other types of bac teria are growing in the mouths of people who are free from tooth de cay and that those types of bacteria which are responsible for tooth decay do not get an opportunity to get a foothold to live in there?

Dr. Orland: That is a very strong possibility, but a great deal more must be known about the really fundamental nature of much of the bacteria which are found around the mouth. Until we can evaluate that better, it is hard to make a definite statement on that point.

Dr. Blayney: Do we always have the same type of bacteria in our mouths, or does it change from time to time?

Dr. Orland: It certainly changes. The infant, when he is first born, has a very sterile mouth, but bacteria soon begin to grow. As the teeth erupt, other types of bacteria come to life there. Again in older people, when all their teeth are lost, perhaps the bacteria again change their types.

The influence of heredity is sometimes also raised as an explanation of why some people have little tooth decay. Heredity can hardly be an important influence, however, when 98 per cent of our children have decayed teeth even though most of their immediate ancestors did not.

In fact, at the alarming rate of thirty-three million new cavities de veloping every year in our six- to eighteen-year-olds, the dental practi tioner just cannot keep up with fillings and tooth extractions. Faced with

problem of this size, prevention is the only solution. To prevent this sease we must know much more about the cause. Intensive research is der way at last.

Well, what specific help can we give our listeners today? On the basis our present knowledge, we can say that to prevent tooth decay we ust begin with the juvenile population. Adults are practically a lost use. One effort which can be made is to refrain from eating excessively veetened foods. Rinsing the mouth with water immediately after eat-g sweets helps dilute out the sugar strapped around the teeth. Brush-g and using some medicated tooth powders or having the dentist paint dium fluoride on the teeth tends to reduce the number of new cavities. For the long run the artificial fluoridation of communal water sup-ies—which is the procedure of adding one part sodium fluoride to a illion parts of drinking water—may prove, after more years of study, be *the* public health measure long needed for mass prevention of tooth ecay.

A NUTRITIONIST'S VIEW OF THE CARIES PROBLEM

By **C. A. ELVEHJEM**

FEW people today question a relation between nutrition and dent caries although the effect of each specific nutrient and its mode of actic still are not known. Early studies did not show definite relations becau it was difficult to diagnose specific nutritional deficiencies in any give population group. Furthermore, estimates of the extent and progre of caries differ greatly, depending on the method used and the trainin and experience of the examiner. There have been serious discrepanci in the results of similar studies, and all conclusions may be subject t question until methods are more carefully standardized.

Most of the surveys, especially those made among Eskimos, Africa tribes and Indians, indicate a lower incidence of caries among those co suming a diet high in milk, meat and raw blood than in those subsistin mainly on cereals, with some roots and fruits. In India, it was foun that there were slightly fewer carious teeth in children whose diet w based on whole wheat than in children who lived principally on ric It also has been observed that the incidence tends to be higher where th diet is considered nutritionally more nearly adequate.

Recent work has been concerned largely with the effect of improve nutrition, or an altered diet, on the prevention and arrest of dental carie These studies are more satisfactory, since each person may be used as h own control.

Researches have shown definitely that the caries increment in th growing child can be reduced by dietary means. The early work i volved the use of diets planned for control of diabetes, containing litt carbohydrate and a high amount of fat. However, the workers on the concluded that the effect was due largely to the nutritional adequacy the diets, and emphasis was placed on the effect of milk, butter and egg Special attention was given to the value of milk, especially raw milk.

Other workers emphasized the value of a well fortified diet low sugar. In several reports from their laboratory an increased inciden of caries was associated with increased consumption of sucrose. On t

ther hand, it has been shown that a nutritionally adequate diet may arry an appreciable amount of dextrose and still have a beneficial effect.

These data clearly indicate that, although dietary control of caries is ossible to a considerable extent, it is still difficult to determine whether ne action is due to systemic or to oral environmental change. In fact, ne recent observations made by Sognnaes emphasize the importance f the lag in time between alteration in the diet and improvement in the ncidence of caries. Perhaps this indicates the importance of systemic ffects.

All these results emphasize the need for animal experimentation. Between 1920 and 1935 considerable emphasis was given to the im- portance of individual nutritional factors in the prevention of dental aries in experimental animals. At that time, however, knowledge of nutrition was insufficient to permit accurate evaluation of individual nutrients; furthermore, most animals showed marked resistance to aries. This may have been partly due to the fact that the animals were tudied for a relatively short period, so that the diets may not have had ime to take effect; but this does not explain the matter entirely. Dogs nave been observed for many years without any indication of severe dis- urbance, and experiments on rats have been carried through several generations with no serious changes.

The development of caries was reported in 1931 in rats fed a diet con- isting of 60 parts yellow corn, 30 parts whole milk powder, 6 parts inseed meal, 3 parts alfalfa meal and 1 part sodium chloride. When oatmeal was used in this ration instead of corn, no caries occurred. The uthors, therefore, concluded that the formation of carious lesions was lependent on impaction of food particles in the molar fissures and that he size of food particles was a contributing factor. Additional work vith a similar ration minus the linseed meal and with 66 parts of corn f various degrees of fineness substantiated this theory. Rice gave similar esults, but wheat did not. Addition of vitamins A, D or C did not re- luce the amount of caries, nor did addition of calcium or phosphorus. . . .

With the development of knowledge in nutrition it has become pos- ible to devise animal diets of which all components are known; yet, ven with such diets, the white rat does not show caries to any extent. t is particularly impressive, therefore, that the cotton rat shows a high ncidence of caries when maintained on these purified rations for ap-

proximately fourteen weeks. The lesions occur principally in the mola sulci, which makes it difficult to apply the observations directly to human caries; nevertheless these studies suggest the existence of fundamenta relations that must be established before further studies can be placed on a sound and satisfactory basis.

In 1944 a high incidence of carious lesions was reported in the sulc of the molars of cotton rats fed the following ration:

Labco casein	18 per cent
Sucrose	73 per cent
Salts IV (Phillips and Hart)	4 per cent
Corn oil	5 per cent
Thiamine	0.25 mg.
Riboflavin	0.3 mg.
Nicotinic acid	2.5 mg.
Pyridoxine	0.25 mg.
Calcium pantothenate	2 mg.
Choline	100 mg.
Inositol	100 mg.
p-Aminobenzoic acid	30 mg.

Vitamins A and D were supplied by feeding 1 drop of halibut liver oil weekly to each rat by dropper.

In later work this diet was modified to include an additional 6 per cent of casein and a supplement of 4 per cent Wilson's liver concentrate powder 1:20 at the expense of sucrose. This modification was found to permit more uniform and more nearly maximal growth without altering the incidence of caries.

The dentition of the cotton rat is similar to that of the white rat; there are one incisor and three molars in each quadrant. The incisors are continuously erupting, and only the first two molars had erupted at the time the experiment was begun. . . .

Studies of the time factor, with experimental periods varying from ten to fourteen or more weeks, showed that fourteen weeks was the optimum experimental period for producing caries. Beyond fourteen weeks fracture became so extensive that individual lesions lost their identity.

The incidence of carious lesions was much higher in the molars of the lower jaw than in those of the upper jaw. The rate of progress was about the same in all molars, but the time of initiation was later for the upper

ci than for the lower. The various molars within each quadrant dif-
ed considerably in susceptibility to decay. The first and second molars
re fully erupted at the beginning of the experimental period, but the
idence of caries was much greater in the second molars than in the
st. The lower third molars were exposed for half or less than half of
e experimental period, but the incidence in the lower third molars
s even higher than in the second molars. The upper third molars were
posed to the oral environment for only about a third of the experi-
ental period and yet showed a high incidence of caries. It appears,
erefore, that diet during the period of tooth development may have
onsiderable effect on resistance to caries. . . .

The effects of different dietary carbohydrates on the incidence and
tent of dental caries have been reported by Schweigert, Shaw, Phillips
d Elvehjem.[1] Very high incidence and extent were noted when dex-
se, fructose, dextri-maltose or maltose was used instead of sucrose
the basal ration. The replacement of half the sucrose by lactose did
t alter the progress of decay. However, when fine dextrin or coarse
xtrin was used instead of sucrose there was a very low incidence.
here was no appreciable difference between coarse and fine dextrin
to results, although more recent work has indicated that some differ-
ce can be observed in the presence of small amounts of sucrose. The
bstitution of dextrin for half the sucrose did not appreciably reduce
e severity of caries, but when three-fourths of the sucrose was replaced
th dextrin the incidence was reduced about 30 per cent.

A study of the effect of drinking water fortified with fluorine indi-
es that fluorine is active in reducing caries in the cotton rat as well as
other animals and in man. When drinking water contained 1 or 2.5
rts per million of fluorine there was no evidence of any reduction in
e incidence and extent of the lesions. Five ppm produced a slight re-
ction, and 15, 30 and 45 ppm produced a reduction of 50 to 60 per cent.
idence of mild fluorine toxicosis was observed in the lower incisors
hen the drinking water contained 5 ppm, and when 15 ppm or more
s present both the upper and the lower incisors were white.
At present it is impossible to correlate the amount of fluorine needed
the cotton rat and that needed to produce an effect in man.

[1] Schweigert, B. S., Shaw, J. H., Phillips, P. H., and Elvehjem, C. A., Dental Caries in the
ton Rat. III. Effect of Different Dietary Carbohydrates on the Incidence and Extent of
ital Caries. *J. Nutrition* 29:405 (June) 1945.

The most interesting observation was made in 1946 when it was fou that cotton rats maintained on a diet of whole milk fortified with irc copper and manganese and liver powder showed no lesions at all. Ev the addition of 5 to 10 per cent sucrose caused few carious lesions. The fore, it appears that under some conditions the animals can consur large quantities of sugar with no detrimental effect. When a dry rati was fed that approximated the composition of milk solids, the numb of lesions was reduced also.

The isocaloric substitution of 10 parts of lard for the sucrose in t basal ration previously described resulted in a 50 per cent reduction the average incidence and a 75 per cent reduction in the average exte of involvement. When 20 parts of lard replaced 45 parts of sucrose the was a 90 per cent reduction in the incidence and extent. The total f content of this ration was 31.7 per cent and the sucrose content was 2 per cent. It is of interest that this ratio is more nearly comparable to th found in the human diet.

When the casein content of the ration was increased from 24 per ce to 50 per cent at the expense of sucrose, a 50 per cent decrease in t number of lesions occurred. When a ration containing 50 parts of case and 10 parts of lard was used, there was almost complete prevention carious lesions. Thus, the levels of fat, carbohydrate and protein ha an important influence on dental caries in the cotton rat. Furthermo the beneficial effect of milk is probably due not only to the higher f and protein content but also to the fact that milk gives fluidity to t ration.

Recent studies have been made in this laboratory on the effect of natural diet compounded in approximation of a typical human diet:

Sucrose	17.3 per cent
Corn oil	3.4 per cent
Mixed breakfast cereals	6 per cent
Bread	30 per cent
Dried whole milk	14.6 per cent
Corned beef hash	9.4 per cent
Dried potatoes	7.1 per cent
Dehydrated pork and beef	6.6 per cent
Dried cabbage	5.6 per cent

This ration produced as many and as severe lesions in the cotton r as did the basal caries-producing diet containing 67 per cent sucro

reasing the sucrose level in the diet to 32 per cent or 47 per cent he expense of cereal did not appreciably affect the incidence. When sucrose level of the diet was reduced to zero or to 2 per cent, the idence of caries was reduced by 80 per cent and 60 per cent respec-ly. Therefore, in a diet of this kind the sugar must be reduced to a y low level in order to affect the occurrence of caries.

Omission of dried whole milk from the diet, with liquid whole milk en separately as the only source of fluid, gave the same results as were ained when the natural diet was fed without liquid milk. In the pres-e of the components of this diet, milk does not give the same pro-tion as that observed when the liquid diet is used.

Comment

n reviewing these studies, it is obvious that many of the effects are ated to oral environment. However, the fact that molars erupting ring the experimental period show changes greater than those ob-ved in the teeth already erupted at the beginning of the experiment ggests that the systemic effect may be important also. This suggests t susceptibility is influenced by a mechanism operating before erup-n of the tooth, which is not surprising.

Certainly one must recognize all factors known to affect the structure a tooth. Nutritionists sometimes place disproportionate emphasis on a gle factor in the prevention of disease, and I hope that dental experts l not fall into the same error. A normal body is dependent on an imum intake of all essential nutrients; therefore, although new data y be added to the general knowledge of dental decay, it is unwise to ore the old, well-established factors. There can be no question that gar plays an important role in dental caries, but several other factors luence the effect of the sugar. At present it cannot be determined defi-ely whether milk carries a specific protective factor or whether a large t of the effect of milk is related to its fluidity. Since important changes noted in the types of intestinal bacteria due to changes of diet, it is at all surprising that important changes take place also in the bac-al flora of the oral cavity for the same reason.

Studies on the relation of nutrition to dental caries have just begun. me practical information may be obtained while a study is in progress, no specific program can be adopted until all the interrelated factors ve been defined clearly.

The People Say...

The following comments are representative of the views expressed by a ROUND TABLE *audience on "What about Retirement?" broadcast June 1951, with H. L. Bills, vice-president of the Acme Steel Company; M Elizabeth Breckinridge, director of the Survey on Industrial Retirement Po cies, University of Chicago; Robert J. Havighurst, chairman of the Comm tee on Human Development, University of Chicago; and Virgil Mart general superintendent and personnel manager, Carson, Pirie Scott and Co pany, Chicago, participating.*

*

Intelligent, Forward Looking

I feel capable and energetic and wish to keep my self-respect by continuing to work for my living. I wish, too, to avoid taking dole of any sort whatsoever whether government or otherwise.

Thank you, fine men, for your intelligent forward-looking progress. I also appreciate your thoughtfulness and kindness in taking up the matter of "age," for which, because of living long over *the* age, we are treated as outcasts or criminals.—*A listener from Brooklyn, New York.*

Shorter Working Days for Older Workers

I listened to your discussion and think that you left out the most important phase of the subject, which is that people, as they get older, get tired before the working day is over and should have, not a day off on Monday or Friday, but fewer hours each day for their work. School teachers, for instance, are under a nervous strain every minute and during their leisure hours are planning for t next day. Other workers who sta at a machine watching details a pushing buttons are also under gr strain. In fact, all workers, in m opinion, when they get older a less vigorous, should work but shou work a shorter day rather than wo ing a long, tiring siege with a wh day off to rest.

I enjoy the discussions of t ROUND TABLE and listen while I a getting ready for church.—*A listen from Whittier, California.*

Why Not Train To Look Forward to Retirement?

After listening to your progra today I had to write this letter. W do all people refer to us who are loo ing forward to our pensions as "O People," when most of us feel we a just young enough and have sen enough to know how to live and e joy life. The whole trouble, as see it, is that you people want us think and to feel that we are too o for any use. When all that we wa

some training to be able to do the ings we have always wanted to do t never had the time.

For example, there was the visit- g schoolteacher in Tennessee who und a community in the Tennessee lls that is as bad as any European im district. She had the time and ucation to help these people and get what help from others that she as not able to give herself. Then ere was the couple who lived near defense area. They were good sales- en and sold the town on the idea of itting up a nonprofit housing proj- t. There are also among us those ho have our hobbies, and we got the ea from the *Popular Hobby* maga- ne. Some have developed these into good business.

I do not believe that there is a per- n in the world who has not had a eam of something which they al- ays wanted to do when they had ne but never seemed to find the ne. So you people as educators and achers who train the young to take eir place in the world, in our places, ain us who now have the time to needed work, such as all kinds of elfare work that is needed in all ies and towns over the country, for ey all say they do not have the oney to employ the help that is eeded.

We start to train our children from e time they enter the first grade to ok forward to the time they will able to take their place as leaders d workers in the world, so why not ep that in mind and keep on train- ing the older ones for the time that they will be able to do the things they never had time to do while rais- ing their families? I personally think that if we would think and work along these lines, instead of always saying you are getting too old to work, that like children we would all look forward to the age of sixty- five if we knew we could and would be trained and used to help.—*A lis- tener from Ogden, Utah.*

Should Start Retirement "Preparation" Years Ahead

Your whole discussion this morn- ing seemed to deal more with the effect of the sore rather than how to prevent the human-relations-in-indus- try-and-elsewhere maladjustment so prevalent in our ever-expanding in- dustrialized economy.

It seems that a serious lack of vi- sion in supervision is exposed when we talk about "preparing" older em- ployees for retirement and then start talking about preparing them at six- ty-two rather than waiting until they are nearer sixty-five. Why shouldn't this talk start at least twenty or twen- ty-five years earlier? And even earlier for the younger personnel? And even before they are hired by their pros- pective employers? In fact, shouldn't this be an essential and definitely re- quired subject for junior high or high school graduation?

Of course, you can say that it's better later than never, but why wasn't anything mentioned about the appalling lack of instruction at home

and in our schools about the ultimate necessity of every individual to live within his or her income? This would tend to stress the importance of learning to do something interesting to themselves as well as useful and important to society.

This obviously could go on much longer. I had intended to write just a brief note. What was said on your program was good, but how can this whole subject of providing be left out?—*A listener from South Pasadena, California.*

Our Thoughts Which Are Important

Your discussion was very interesting indeed, especially because I personally am of retirement age—so called. My candid opinion is that it is all in a man's consciousness, his own personal self, his own thinking. We are what our thoughts are. I started working away from home at ten. Sixty-five is already under the bridge. I still work eight hours per day, five days per week, occasionally six. I own my home and an acre of ground, and I keep it up. It takes all my spare time, but I get a lot of enjoyment out of it. Until two years ago, I could keep up with the best of them. I could yet if I just worked my eight-hour shift and let it go at that. I retire between one and two A.M. and rise between eight and eight-thirty. I am fond of reading, gardening, construction, and interior decorating.—*A listener from Garden City, Michigan.*

Set Up Training Workshops and Studies

Because this is a very timely subject, I cannot let it go unanswered. As a matter of fact, I believe I am a good subject to prove a point which you have omitted. Professional women like myself who are alone in the world after their only child has been married, for which I am very grateful, usually have to take that bitter pill by going to work for their own married children. We are forced to retire because no one wants to give us work. . . .

I would suggest that each state should have all sorts of workshops and studios, and as soon as a person fails to obtain work on account of age that he or she is fit to do, they should work in those places established by the states in honor and dignity in order to spare them humiliation, which helps to break the spirit and the nervous system. Remember, those citizens who care that much to work and who do not want to be floating around in all sorts of charity institutions are worth while saving from disaster. We need such people; they do not get old so fast, they keep on working until they drop dead.

If older people cannot be permitted to make a living, through no fault of their own but the only crime against them is that they have the nerve to live so long, why not chloroform them or teach them how to go to sleep like Rip Van Winkle until they can be of an age to receive their pensions?—*A listener from Los Angeles, California.*